Free Convection of Household Heater

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Free Convection

Objective: Determine how much heat is transferred from the side of the heater toward the other room due to free convection.

Assumptions:

- No forced convection, only free convection
- Constant, uniform surface temperature

Free Convection

Dimensions/Constants:

T_s= 333 K (140° F)

T_∞= 293 K (68° C)

$\Rightarrow T_f = 313$ K

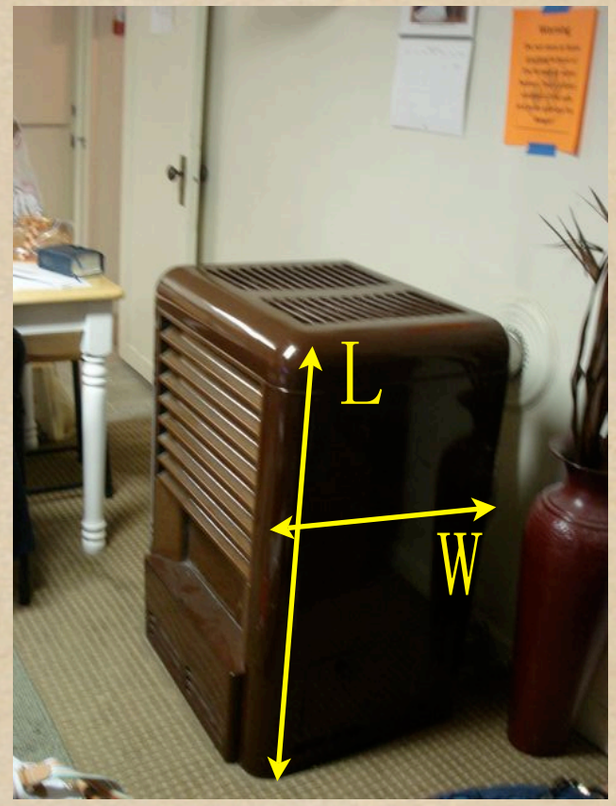
W = 0.33 m

H = 0.80 m

υ = 17.2e-6 m^2/s

Pr = 0.705

$\beta = 1/T_f = 0.00319$ k^{-1}



Free Convection

$$Gr_L = (g\beta|T_s - T_\infty|L^3)/(\upsilon^2)$$

$$= 2.17 \times 10^9$$

$$Ra_L = Gr_L \cdot Pr$$

$$= 2.17 \times 10^9 (.705)$$

$$= 1.531 \times 10^9$$

$\Rightarrow$ Use eq. 9.26

Free Convection

$$Nu_L = \{0.825+(0.387Ra_L^{1/6})/(1+(0.492/Pr)^{9/16})^{8/27}\}^2$$

$$= 140$$

$$\Rightarrow h = (K/L)Nu_L$$

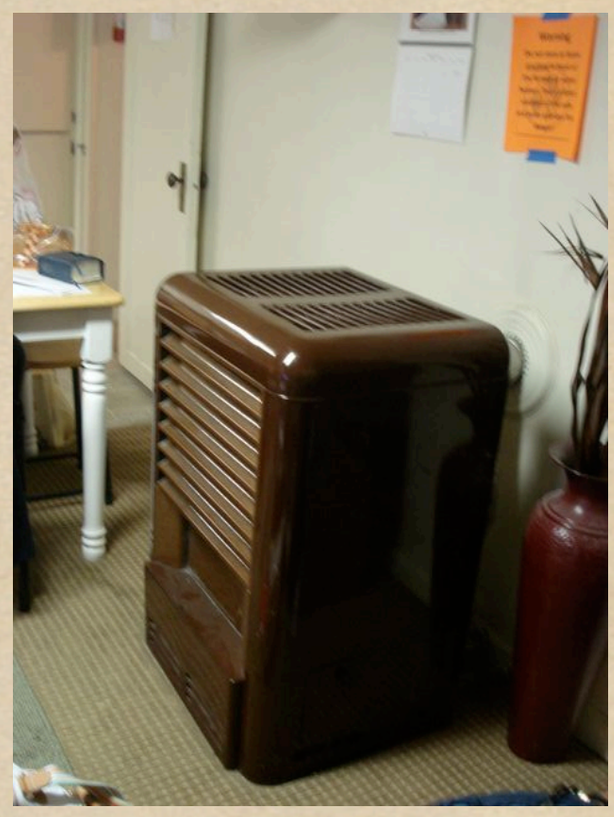
$$= 4.78\ W/m^2K$$

and

$$q = h \cdot A(T_s - T_\infty)$$

$$= 4.78(0.8x0.33)(40)$$

$$= 50.5\ Watts$$



Comments

These results were from only considering free convection. Radiation would be a significant source of heat transfer as well, in comparison. Assuming $\varepsilon = 0.5$, heat transfer by radiation would be about 36.9 Watts.

From comparing Reynolds number to the Grashof number an induced wind speed of about 2 m/s (4.5 mph) would produce a significant source of heat transfer as well.